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CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 8, Issue, 6, pp. 17421-17424, June, 2017

ISSN: 0976-3031

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

sEMG FREQUENCY ANALYSIS IN MUSCLES ELBOW

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DOI: http://dx.doi.org/10.24327/ijrsr.2017.0806.0350

ARTICLE INFO

Article History:

Received 17th March, 2017
Received in revised form 21th April, 2017
Accepted 28th May, 2017
Published online 28th June, 2017

Key Words:

Biomechanics; Median Frequency; Biceps Curl; Isometric Contraction; Torque.

ABSTRACT

The elbow flexion is a movement that can be trained and that resistance exercises are essential for improving the strength of muscle contraction. To determine the force being carried by the muscle during contraction is necessary to calculate the torque. While this is to analyze how the behavior is used myoelectric electromyography. Therefore, the objective of the study is to recognize patterns of electromyographic signals in the frequency domain in an isometric contraction of elbow flexion in the biceps curl machine at angles of 30°, 45°, 60° and 90°. For this study we used 20 male participants with a mean age of 22.5 ± 3.5 years, no diagnosis of musculoskeletal diseases and physically active. Among the results noted that the external torque at the angle of 90° is larger compared to other angles, and the median frequency decrease. In median frequency pattern, maximal voluntary isometric contraction (10 sec), can see the dip in form, i.e., it is possible to reach the neuromuscular fatigue in this type of contraction. And the median frequency has a crush on all fragments of angles, following the initial to the final, except in the 90º, which was statistically no difference seen.

INTRODUCTION

The biomechanics is the application of mechanical in the biological system, or the mechanics applied to living beings (1). A theme that relates and interacts with kinesiology, is arthrokinematics. This investigates the movements that occur between the articular surfaces during mechanical movements and physiological (2).

An example of these movements is the movement of flexion and extension of the elbow, which is carried by the joints and umeroradial humerus-ulna, and these only one degree of freedom (3). In the elbow the maximum amplitude of the passive movement which is usually found is 5 degrees beyond the extension (hyperextension) and up to 145 degrees of flexion(2).

It is known that the application of muscular force, related to the distance from the rotational axis of motion of the segment, to move an external resistor provides a specific feature of force to the component of angular movement, known as torque or moment of force(4).

And the speed of contraction, and the contraction type (concentric, eccentric, isometric), another factor that may influence the magnitude of torque is the angular velocity, that is, according to the increase and decrease the angle of articulation of the muscle group who is making the torque can be smaller or larger, because the speed of contraction(5).

The external torque can be defined as torque generated by an external load on the segment of interest. This case is often seen in training gyms and strength due to the use of a load to perform the counteracting force, so that the external torque can have multiple values due to the different ranges of motion to be processed(6). This process may have changes in the speed of contraction, as the muscle fibers that are innervated by motor neurons, show different shortening velocities thus varying the frequency of depolarization of motor units.

To understand and evaluate the myoelectric activity and muscle torque, a form used for this type of study is electromyography (EMG). The EMG can be defined as a technique for detecting, capturing and analyzing the electrical signal from the muscle contraction performed (7).

To investigate the peak torque from muscle contraction, can be said that electromyography has been widely used to analyze myoelectric signals. From these signals it is possible to carry out pattern recognition of the behavior muscle function of time according to the range of movement carried out, for example,

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the root mean square (RMS), but also in the frequency domain(8), such as the mean frequency (Fmean), median frequency (Fmedian) and peak frequency (Fpeak).

The electromyographic analyzes can be done by invasive or superficial. The invasive method while bringing greater precision values and methodological quality, with needle or wire electrodes, can generate a very large discomfort in placement, plus a enhancement and complexity during the exam. While the method is used surface through surface electrodes adapted to estimate the behavior of the speed of action potentials of motor units (8,9).

The electromyographic analysis can provide us with data to observe possible frequency values due to the decrease in firing rate of motor units, ie, this event may be causing fatigue and decreased muscle strength (10,11).

Thus, we can say about the importance of performing a spectral analysis of the behavior of the electromyographic signal (SEMG), undergoing a maximal isometric contraction. For accordance with the frequencies obtained by SEMG, it is possible to indicate at what time of the contraction there will be greater power spectrum reacted as the same throughout the support load when the motor unit has failed, causing the frequency oscillated generating a large margin of error, conduction velocity of the muscle fiber or even greater recruitment of motor units.

Moreover, it is possible to establish a relationship between: the external torque and their different angular variables, with the behavior of motor units during the action of torque and its variables. This can be developed for individuals who use the isometric contraction with greater frequency in daily and sports that require isometric contraction.

Thus, our goal was to recognize patterns of electromyographic signals in the frequency domain in an isometric contraction of elbow flexion in the biceps curl machine at 30º, 45º, 60º and 90º and relate the frequency of the external torque.

MATERIALS AND METHODS

Subjects

This study included 20 male participants with a mean age of 22.5 ± 3.5 years, no diagnosis of musculoskeletal diseases and physically active. This test sample was calculated by linear correlation sample with a significance of $p < 0.05$.

In order to maintain homogeneity among participants was mensurada12 body mass, height and skin folds. According to these data was obtained parameters of inclusion or exclusion of the sample, and for the analysis suggested was adopted fat mass percentage of 10 to 14% and BMI 18.5 to 24.99 (health indices for age 18-29 years) (13), since these factors could affect the results of electromyographic capitation.

Worrying about the integrity of the participants, the overall risks are related to physical exertion (musculoskeletal injuries, nausea and dizziness) that occur with low frequency in controlled conditions. There was a person next to equipment at the time of undertaking the exercise to assist the volunteer; the individual does not produce force before collection.

Before the analysis all participants signed an informed consent according to the guidelines of the Ethics Committee (CAAE: 02121612.4.000.5150).

Recording data

To recording of surface electromyographic signals (sEMG) surface electrodes (MedTrace - Ag / AgCl) were used, respecting the distance between electrodes (center-center) 10mm, which were placed on the *brachioradialis* and *biceps brachii* muscles (14).

To reduce possible interferences in the passage of electrical stimulation was performed prior to placing the electrodes, shaving and cleaning the skin with alcohol, the level of the muscle studied. The reference electrode was placed on the patella.

To obtain the surface electromyographic signals of one (EMG System do Brasil) module for acquiring biological signals from eight (08) channels were calibrated with a gain of 1000 times, with a 10Hz high-pass and low-pass filter was used 500Hz with a sampling frequency of 2000Hz and common module rejection 120dB.

For the record of maximum voluntary isometric contraction (MVIC) was used a load cell (EMG System do Brasil), with a capacity of two thousand Newton (2000N), which was positioned perpendicular to the direction of the mechanical axis.

After it was done the digital processing of the sEMG data that provided the median frequency (Fmedian) of each record obtained during exercise, as well as analysis of the fast Fourier transform (FFT). The digital signal processing were made using Matlab® software.

Proceedings

The exercise used in this study is elbow flexion at Banco Scott. The place used to carry out the collection was the Laboratory of Exercise Sports Center, Federal University of Ouro Preto.

For standardization of the execution of the movement, the individual sat in the biceps curl machine, in a way that his feet were flat on the ground, the trunk slightly bent forward in a way that touched his chest. Parallel arms resting on the biceps curl machine, hands in supination without locking the elbows.

The values of the electromyographic signals and isometric external torque at angles of 30º, 45º, 60º and 90º were analyzed. Each subject performed a contraction using the maximum force in each range of motion for 10 seconds. The results of three angles were collected in one day and two angles in another day selected randomly in each individual, respecting the recovery time of five minutes between the angles and the 48 hours between collection days.

To calculate the external torque, equation (1), where the measurement of the force arm was done with the caliper (Kingtools) the dominant upper limb was used. It was adopted as anatomical landmarks lateral epicondyle of the humerus and the styloid process of the radius (12).

$$\text{Force x Distance x } \sin(\alpha) = \text{Torque external} \quad (1)$$

RESULTS

The relative values of the external torque at angles of 30º, 45º, 60º and 90º in the initial, middle and final fragments show an increasing behavior of the moment of force (Figure 1) where the initial fragments, middle and end in angles 30º showed significant differences ($p \leq 0.05$) compared to other angle and their fragments.

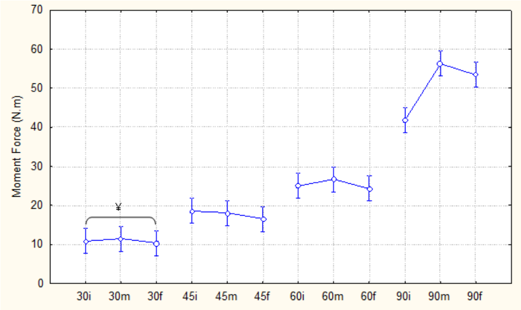

Fig 1 Relative values of the external torque at angles of 30º, 45º, 60º and 90º in the initial (i), middle (m) and final(f).

Figure 2 shows the values of Fmedian the *biceps barchii* muscle at angles of 30º, 45º, 60º and 90º where the value of 90i has significant difference compared to 30i and 45i. The values of the Fmedian 90m and 90 f were significantly different regarding their respective fraction at angles of 30º, 45º and 60º.

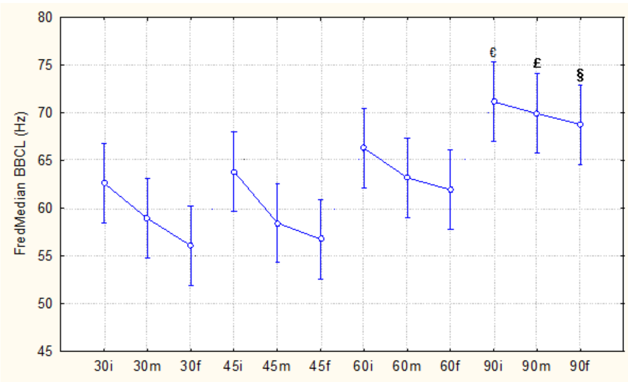

Fig 2 Values of the median frequency (FMedian) th *biceps brachii* long head (BBCL) muscle at angles of 30º, 45º, 60º and 90º in the initial (i), middle (m) and final(f).

Analyzing the values of Fmedian *biceps brachii* short head muscle there is a significant difference ($p \leq 0.05$) in the 90m compared to 30m and 45m (Figure 3).

The values of the *brachioradialis* muscle showed no significant difference in the values of the angles Fmedian and its fractions (Figure 4).

DISCUSSION

In Figure 1 we have the results of the moment of force in relation to the angles worked during the study, and these are fragmented angle in the beginning, middle and end, for better interpretation of the data.

The results observed in relation to the torque production are shown in Figure 1, and this demonstrates the Y amplitude and intensity of the torque versus time axis, which is being represented on the X axis this torque production is related to a maximal voluntary isometric contraction (MVIC), each at a different angle determined.

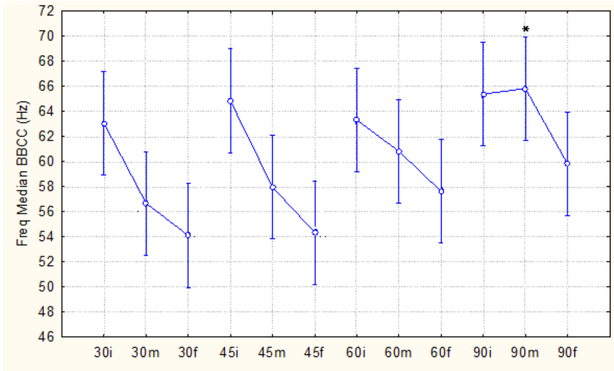

Fig 3 Values of median frequency (FreMedian) of biceps brachii short head (BBCC) muscle at angles of 30º, 45º, 60º and 90º in the initial (i), middle (m) and final(f).

Having sourced from figure 1, we can say that the moment of force at a 30º angle and its due fragments did not show significant differences. While 45º, 60º and 90º show significant differences. Note-if the discrepancy of torque at 90º in relation to the other angles, noting that the average fragment 90º is greater than the initial fragment, after causing a fall towards the end, but no significant difference could reflect the onset of neuromuscular fatigue.

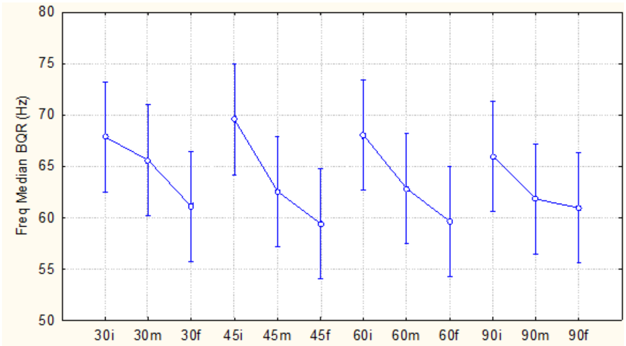

Fig 4 Values of median frequency (FreMedian) of *brachioradialis* (BQR) at angles of 30º, 45º, 60º and 90º in the initial (i), middle (m) and final(f).

With this it was possible to observe that the lower torque production was during flexion angle of 30º and greater torque production was at an angle of 90º of elbow flexion. This is because the mechanical advantage, which is the ratio between the arm and the power resistance arm (16).

Peak torque was found about close to 2 seconds after the MVIC, considered that the contraction was performed after 1 second collection began, precisely in order to analyze the relationship between the force and the second time of muscle contraction.

The figure 2 represents the median values found in the frequency of the *biceps brachii* muscle EMG long head (BBCL), and the Y-axis represents measured in Hertz (Hz) of the frequency signal and the X axis are represented the beginning of collection angles (i), medium (m) and end (F).

Thus it was observed that the frequency of depolarization of motor units decreased in all angles and can conclude that it was actually held one MVIC and in the course of this individuals were coming to a neuromuscular fatigue. And all scales occur a decrease in the median frequency of fragments starting from the initial to final results for each angle, except for the angle of 90º, that statistically there was no significant decrease in the frequency of sampling.

Another aspect observed referring to Figure 2, is that the depolarization frequency increases with the angle, that is, from the time that the bending angle increases while the intensity of the frequency increases to 90º.

The figure 3 shows a similar behavior, with a decrease of frequency of initial fragments to the finals in each angle, showing that individuals were heading for a neuromuscular fatigue at BBCC. Only the 90º angle is greater depolarization in intermediate moment of contraction in the initial and final fragment.

In Figure 4 the *brachioradialis* muscle and the relationship between the median frequency and the angles that were worked.

As you can see, this muscle also there was a decrease in frequency compared to the fragments of the angles of the initial to final. A different description of this figure is that at 90º the intensity of depolarization is not larger than the other angles, as in other angles . Showing that the brachioradialis contraction in 90º of flexion of the elbow has great influence in this action as the other muscles, referring to the same angle of 90º.

Regarding the study was observed similarity of the electromyographic behavior in relation to the external torque responsible for elbow flexion, similar to the students who performed as a function of the lower limb muscles (17). There was a greater depolarization of motor units at the beginning of each fragment angle, this happens due to the high rate of firing of action potentials at the beginning of the movement, so that at the end of the year to maintain the load remains the same, i.e., decreases depolarization, but the fall of torque and force is not (like) with the firing rate.

Therefore, this research shows that the moment of external force or torque in a MVIC at 90º angle is greater in relation to angles of 30º, 45º and 60º. And in 30º there is no difference between final and initial fragment, medium and while others no difference. Regarding the electromyographic behavior, can say that in MVIC 10 seconds can see the dip in form, i.e., it is possible to reach the neuromuscular fatigue in this type of contraction. And the median frequency has a crush on all fragments of angles, following the initial to the final, except in the 90º angle, which was statistically no difference seen.

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How to cite this article:

Vinicius Martins Paula *et al*.2017, sEMG Frequency Analysis In Muscles Elbow. *Int J Recent Sci Res.* 8(6), pp. 17421-17424. DOI: http://dx.doi.org/10.24327/ijrsr.2017.0806.0350